Nitrogen management in barley

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Take home messages

- *All varieties responded similarly to applied N.*
- *Hindmarsh and Commander yielded well; all varieties achieved Malt.*
- *In 2010, there was no negative effect on grain yield and quality from delaying N until mid-tillering.*

Background

This trial forms part of a continued GRDC tri-state funded project (DAV00138, building upon DAV00104) involving NSW Industry and Investment, SARDI and BCG. Both projects were designed to investigate the responses of new and current barley varieties to specific aspects of agronomy in a no-till farming system. These include responses to time of sowing, applications of nitrogen (N) and phosphorus (P) and disease management (particularly scald).

Varieties have different characteristics that can influence other factors such as nitrogen management and weed competition. Hindmarsh possesses a semi-dwarf gene which causes its erect leaf habit and slower early growth. This can reduce competition with weeds early in the season and also allow greater light penetration through the canopy later, further favouring weed survival. One theory, particularly in the Mallee, is Hindmarsh may require, or yield better if more N is applied at sowing. The theory is also intended to increase the vigour and subsequent competition of Hindmarsh against weeds such as ryegrass and brome grass.

This paper investigates whether various varieties respond differently to N.

Aims

1. To evaluate the response of barley varieties to applied nitrogen rates at sowing
2. To determine whether varieties respond differently if N is delayed until mid-tillering

Method

To ascertain whether barley varieties differ in their responsiveness to applied nitrogen, two replicated field trials were established in cereal stubbles at Culgoa and Lubeck. In a randomised complete replicated block design with 3 replicates, nitrogen (8) and variety treatments (4) were completely randomised within. Each replicate was laid out over three ranges, to try to ensure that all treatments were as close to one another as possible, enabling viable comparisons between response curves for each variety. The same design was used at both sites.

Replicates:	4
Target seeding density:	140 plants/m^2

Fertiliser:	50kg/ha MAP (at sowing)
Seeding equipment:	Knife points, press wheels (30cm spacings)
Varieties:	Buloke, Hindmarsh, Commander and Gairdner barley
N rates and timing:	(i) at sowing: 0, 20, 40, 60, 100, 150kg N/ha (ii)mid-tillering: 100kg N/ha (iii) split application: 40kg N/ha pre-drill followed by 60kg N/ha at mid tillering.

Table 1: Paddock history and soil analysis at Culgoa and Lubeck.

Analysis	Culgoa	Lubeck
2009 crop	Barley	Oaten Hay
Sowing date	20 May	13 May
Soil type	Clay Loam	Wimmera Clay
Growing Season Rainfall (GSR)	248mm	311mm
Annual Rainfall	511mm	627mm
Colwell P (mg/kg)	34	21
Organic Carbon	0.98%	1.44%
PAW* at sowing (0-100cm)	16mm	62mm
Total available N (0-100cm)	68kg N/ha	53kg N/ha
pH (water) – topsoil (0-10cm)	8.3	7.2

**PAW = Plant available water*

Roundup PowerMax (2L/ha) and TriflurX (1.5L/ha) were applied 2 hours prior to sowing. Seed bed moisture at sowing, though close to marginal, was nevertheless sufficient to ensure germination at both sites. Granular Urea was used for all treatments.

Culgoa

The up-front nitrogen treatments were deep-banded at seeding. The in-crop applications were applied using a hand-held garden spreader on the 24 June. The site received 5mm of rainfall on the following day.

Tilt (500mL/ha) was applied to all plots for scald on the 22 August and 12 October. Agritone 750 (200mL/ha) + Ally (3g/ha) was applied for broadleaf control on the 27 June. The trial was harvested on the 23 November.

Lubeck

The seeder used to sow this trial was not equipped for deep banding. As a result, the up-front nitrogen treatments were pre-drilled prior to seeding. The in-crop applications were applied using a hand-held garden spreader on the 29 June. The site received 25mm of follow-up rainfall over the following four days.

Tilt (500mL/ha) was applied to all plots on the 27 July for scald. Agritone 750 (500mL/ha) + Ally (5g/ha) was applied on the 7 July for broadleaf control. Dimethoate (400mL/ha) was applied to control aphids. The trial was harvested on 23 December.

Data recorded throughout the season included: plant densities after emergence, dry matter at end of tillering, flowering and maturity and grain yield. Quality parameters were measured.

Gross income (yield t/ha x grain price) was determined after classifying individual plots as Malt or Feed, based on quality parameters. Cash price from AWB Birchip on 23 December, consistent with the rest of this publication, was used to establish returns.

An analysis of variance was used to test for significant effects of treatments and interaction between treatments. Least significant differences were calculated at the 95% confidence rate.

Weather conditions and rainfall at both sites (Culgoa and Lubeck) were measured using a Campbell Scientific Aust. ET107 automatic weather station.

Results

Did varieties differ in their response to N?

For a variety to be more 'nitrogen efficient' than another, it simply means it achieves the same yield on less N (assuming everything else is equal). Despite there being a positive response to applied N at both sites in 2010, no variety was found to be significantly different from another. Further investigation may be required for Gairdner and Hindmarsh.

With a low to moderate initial soil N, applying N at sowing increased grain yields and protein incrementally with N rate (Figure 1). Yields were strongly influenced by variety ($P<0.001$, LSD 0.25, CV 8.1%) and the rate of N ($P<0.001$, LSD 0.30, CV 8.1%). However, all varieties responded to the same degree to increasing amounts of N ($P=0.66$). For example, applying 60kg N/ha produced the same yield increase for Hindmarsh as it did for Buloke.

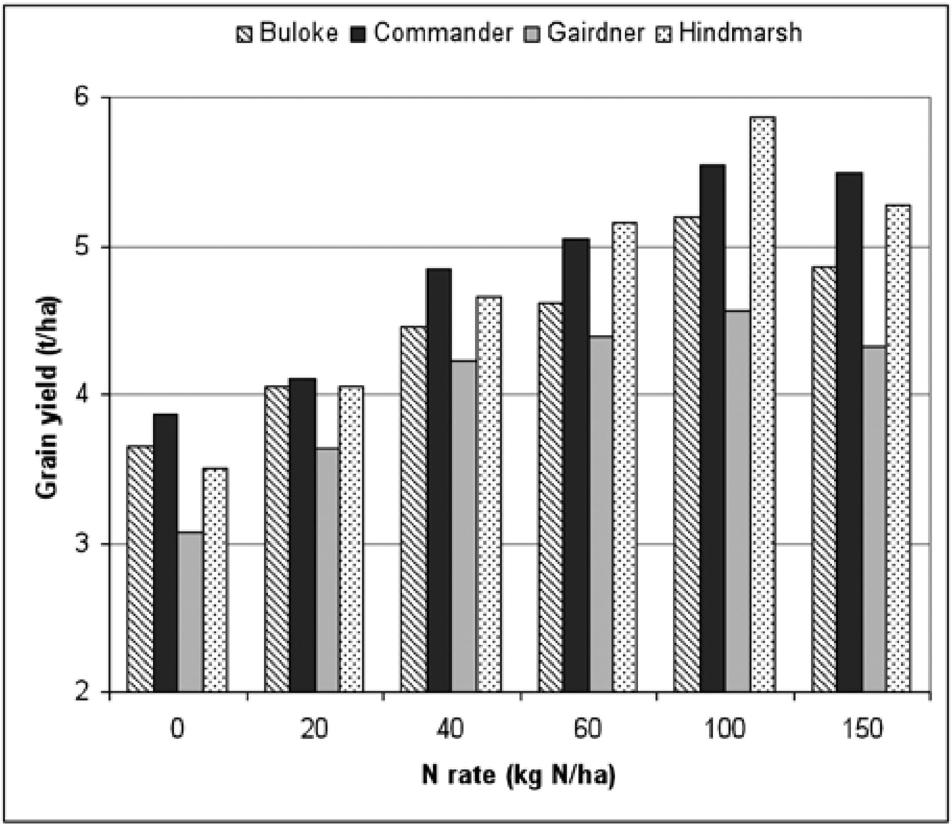

Figure 1. Culgoa barley grain yields for different rates of N applied at sowing.

Plant establishment of all varieties was reduced with increasing rates of N, especially at the 150kg N/ha rate. As N rates increased, more incidences of seed contact with fertiliser granule would have occurred. The reduction was not observed in the number of shoots measured at GS30 or heads at flowering which would indicate that the crop was able to compensate by producing more shoots later at the higher N rates. The lowest establishment occurred at the 150kg N/ha rate. This effect would have contributed to the reduction in yield at the higher rate compared with the 100kg N/ha.

The same yield trend was observed in grain protein, with differences found between varieties (P=0.003, LSD 0.67, CV 10%) and N rate (P<0.001, LSD 0.82, CV10%). Figure 2 shows that Hindmarsh achieved protein levels for Malt (9 – 12% protein) at all rates except at 20 and 150kg N/ha. Buloke met the Malt grade at all rates of N (except nil). Commander did not achieve greater protein level than 9% at any rate below 100kg N/ha.

Culgoa

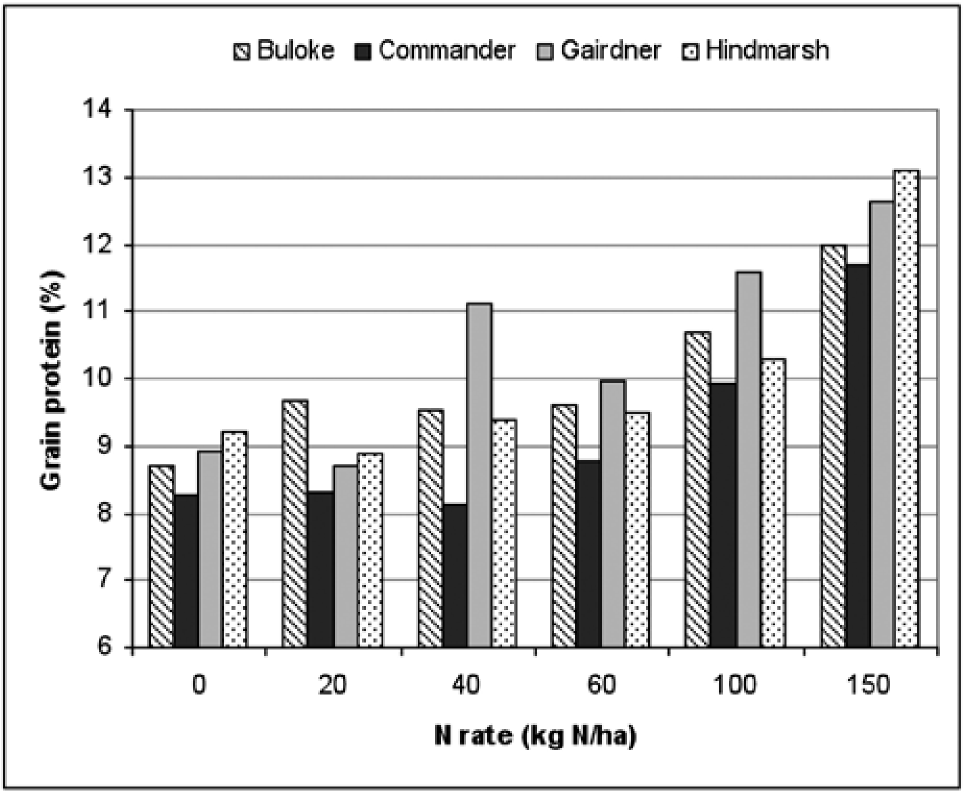

Figure 2. Grain protein levels for different rates of N at sowing at Culgoa.

Lubeck

Responses of the varieties to various rates of applied N were similar at Lubeck to those observed at Culgoa. Grain yield increased with more N, but yield plateaued depending on variety at 5.0t/ha. Yields were strongly influenced by the rate of N (P<0.001, LSD 0.5, CV 15.2%) and varietal choice (P=0.002, LSD 0.4, CV 15.2%). As was the case at Culgoa, no variety responded differently to the rate of N from another (Figure 3).

Lubeck

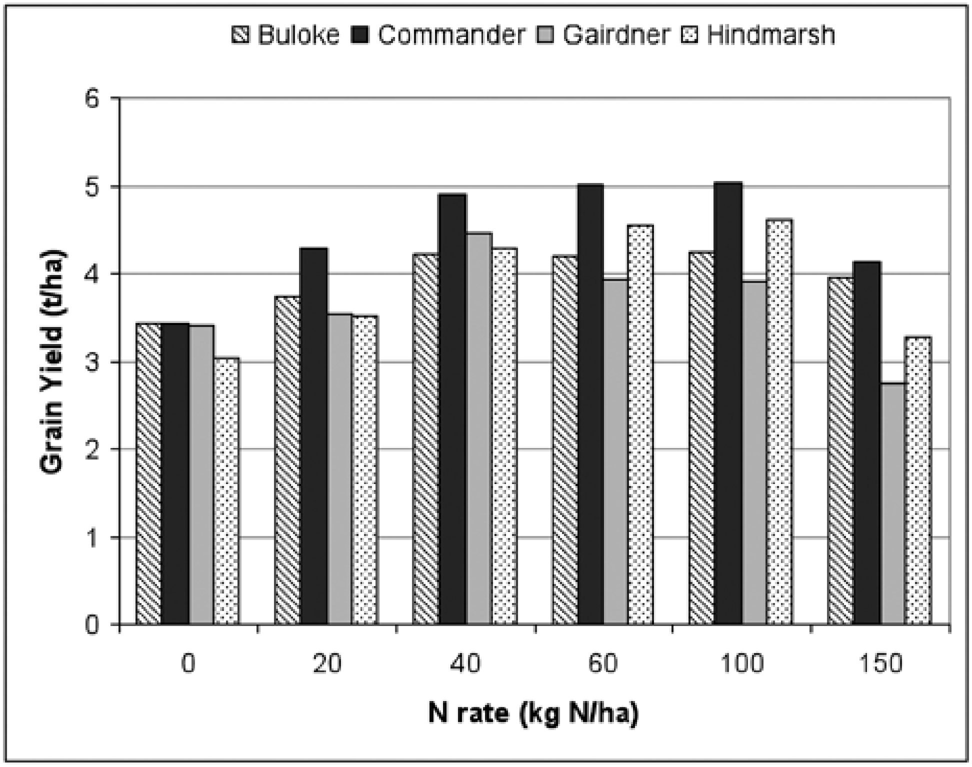

Figure 3. Change in grain yield between varieties with increasing rates of nitrogen applied at sowing at the Lubeck site (Variety x N rate was not significant).

Plant establishment issues were more severe at Lubeck than Culgoa. The mean plant density was 75 plants per metre square: much less than at Culgoa (101pl/m^2). The ability of the crop to recover from lower densities may have been one of the reasons yields reach a plateau at 40 – 60kg N/ha. No difference in the number of shoots occurred as a result of increasing the N rates at GS30. This would mean that, despite the reduction in establishment, barley was able to increase yield by compensating with more shoots, to a certain extent.

A higher organic carbon (1.44%) at sowing could have contributed more mineralised N during the growing season, increasing the amount of available N to the crop. This could have been the reason yields did not continue to increase at higher rates (60 and 100kg N/ha rates). The site also experienced waterlogging during August and September which could have meant some applied N was lost through denitrification.

Grain protein also increased with applied N rate, as was the case at Culgoa (Figure 4). Interestingly, protein levels did not increase dramatically, despite there being no extra yield at the 60, 100 and 150kg N/ha rates.

Did the timing of nitrogen affect growth yield or quality?

Grain yield and protein of four varieties were compared using the same N rate (100kg N/ha) at both sites at three different growth stages: sowing, mid-tillering and a spilt application (40kg N/ha at sowing, 60kg N/ha at mid-tillering).

At Culgoa, delaying N application until mid-tillering increased the grain yield of each variety compared with applying it at sowing (P=0.002, LSD 0.26t/ha, CV 5.7%). In all varieties but Hindmarsh, yields improved using a split approach (e.g. some at sowing, the rest at mid-tillering) rather than the upfront treatment.

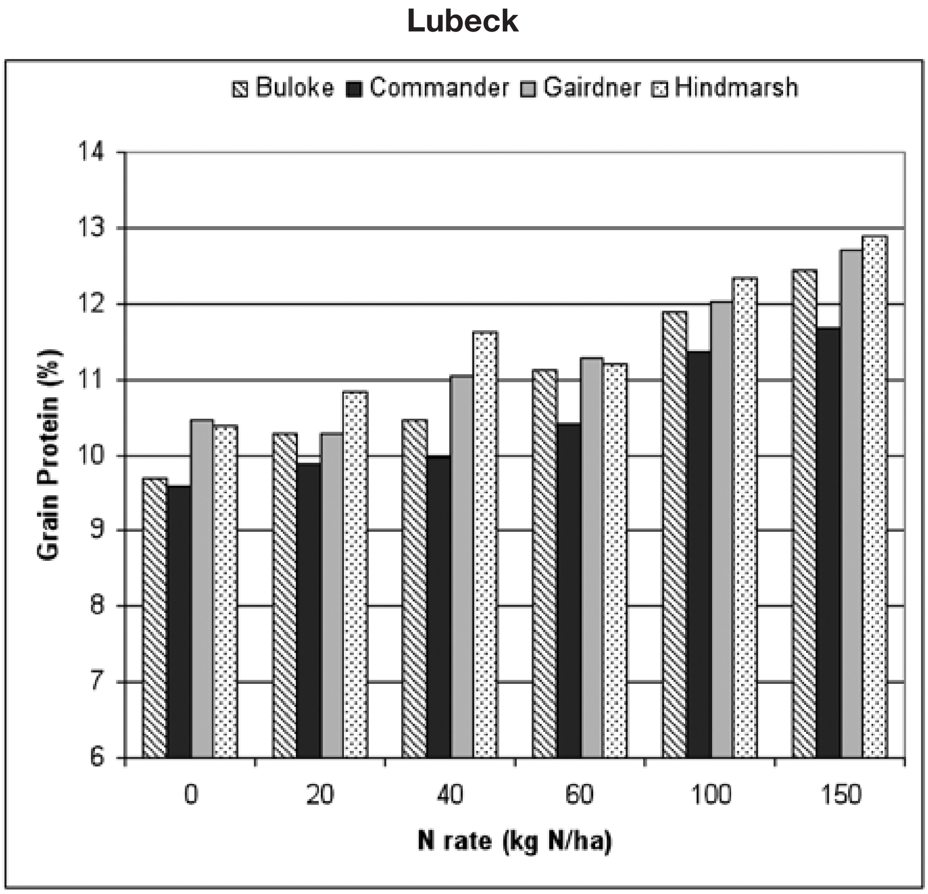

Figure 4. Change in grain protein between varieties with increasing rates of nitrogen applied at sowing at the Lubeck site (not significant, CV 4.6%).

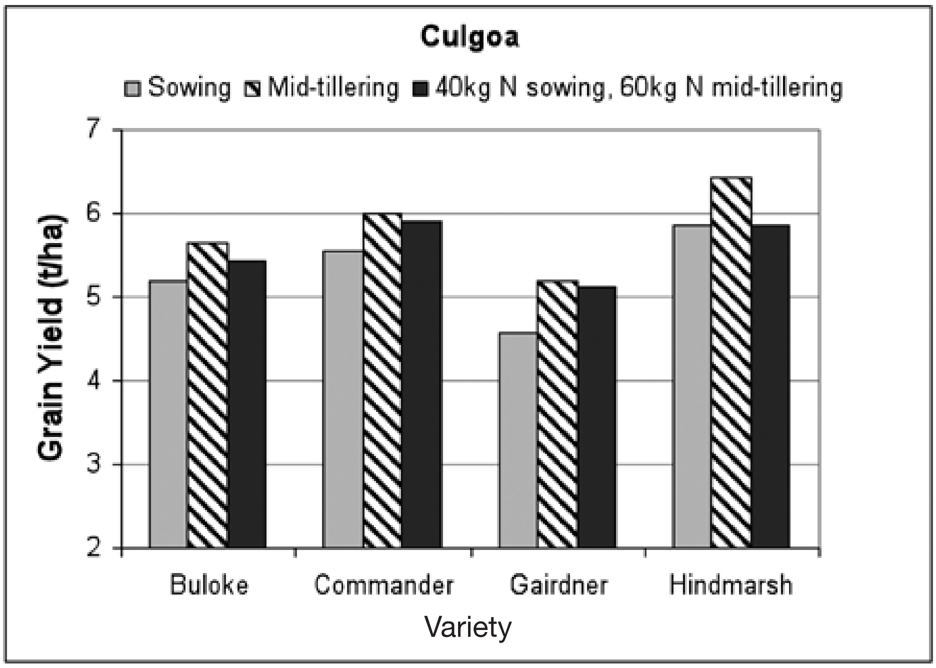

Figure 5. The effect of different N application timings on grain yields of different barley varieties at Culgoa (P = NS, LSD = 0.53).

In terms of grain protein, Buloke results were similar at each N timing, whereas protein levels of Commander and Hindmarsh were reduced with the later applications (P=0.057, LSD 0.9%, CV 4.7%) (Figure 6). This is contrary to previous findings. However the later applied N may have been converted more into yield, diluting the protein content. Differences in Gairdner were not significant.

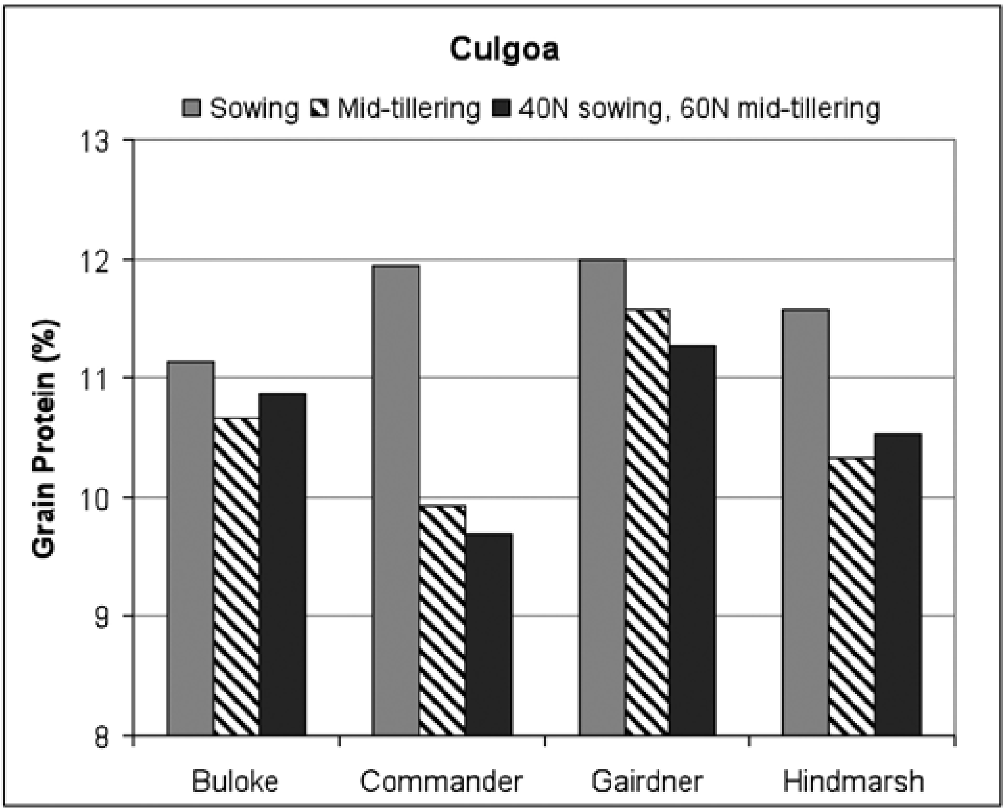

Figure 6. *Grain protein levels obtained at the different N timings at Culgoa.*

At Lubeck, there were no significant differences found in either grain yield or protein according to when the N was applied.

How did the varieties perform?

Theoretical gross incomes were calculated for both sites using the yield and quality of each variety at the optimal N rate. For Culgoa, the highest yield and best quality for all varieties was achieved at the 100kg N/ha rate (Table 2). At Lubeck, all varieties performed best at the 60kg N/ha rate.

Table 2. Theoretical gross incomes of the varieties achieved from applying the 100kg N/ha rate at Culgoa (cost of N not included).

Variety	Grain Yield (t/ha)	Grain Protein (%)	Grade	Price ($/t)	Gross income ($/ha)
Buloke	5.2	10.7	Malt 1	253	1,316
Commander	5.5	9.9	Malt 1	253	1,393
Hindmarsh	5.9	10.3	Hind 1*	228	1,345
Gairdner	4.6	11.6	Malt 1	253	1,164

**Hind 1 = Segregated grade of Hindmarsh barley that achieved Malt 1*

At Lubeck, a similar trend in crop production and quality was found, although the test weights in all varieties were less than 62.5 (harvested after the rain) which is the minimum standard for Malt 2. This meant that no variety achieved Malt classification. The highest yielding variety achieved the highest gross income as the price was the same for all. The price used in Table 3 uses the grain receival price at AWB Birchip on 23 December. There was no nearby receival point taking Feed 2.

Table 3: Theoretical gross incomes of the varieties achieved from applying the 60kg N/ha rate at Lubeck.

Variety	Grain yield (t/ha)	Protein (%)	Test weight (kg/hl)	Grade	Price ($/t)	Gross income ($/ha)
Buloke	4.2	11.1	60	Feed 2	131	550
Commander	5.0	10.4	62	Feed 2	131	655
Hindmarsh	4.6	11.2	63	Feed 2	131	603
Gairdner	3.9	11.2	61	Feed 2	131	510

Malt 1: Protein 9-12%, Retention > 70, Screenings <7%, Test Weight > 65kg/hl

Interpretation

N responsiveness

There was no evidence in this study to suggest that varieties, even with different characteristics, respond differently to N rates applied at sowing. However, Hindmarsh in the past two years of this study, has been very responsive to N. At both sites, Hindmarsh, had the greatest change in yield from increasing rates of N applied at sowing, which is consistent with the Woomelang findings in 2009. If further investigations support these findings, especially in similar seasons with higher N rates applied, it may identify a greater yield potential for Hindmarsh than other varieties.

Nitrogen timing

In recent years, growers have adopted a compromise position between achieving early vigour and growth and spreading risk by delaying N application. Early vigour and growth is effective in reducing the impact of diseases such as rhizoctonia, while delaying N helps reduce financial risks in drier seasons.

In a wet year, it could be expected that there would be a yield penalty from delaying N application. However, findings in 2010, a wet year, showed that delayed N can increase yields. At both sites, topsoil N may have been sufficient to maintain growth until mid-tillering. Delaying N until mid-tillering converted more of the N into biomass later in the season (flowering) than early biomass (GS30). This extra biomass was converted into yield as reflected by the yield difference.

Commercial Practice

This study has a much wider focus than merely this year's findings. Information collected will go towards a national understanding of how barley varieties respond to various management practices. Data will also be used for modelling purposes in APSIM.

What can be learnt from this study is that having the right variety at the wrong nitrogen rate is more costly than having the wrong variety at the right N rate. For example, at Culgoa, Hindmarsh at 20kg N/ha yielded 4t/ha, while Gairdner at 60kg N/ha produced 4.4t/ha. Given the cost of N is $1.30/kg N, growing Gairdner at 60kg N/ha would be $60 more profitable than Hindmarsh at 20kg/ha. This is especially the case on very responsive sites such as Culgoa in a wet year.

The difference between growing Hindmarsh and Commander has for the past two years come down to the price differential between Malt and Feed. By choosing the variety best suited to your farm, with sound N management, better yields and profitability will be achieved.

From this study, it would seem that using a 'split timing' strategy would serve both purposes well: lowering financial risk while addressing other agronomic issues such as rhizoctonia and/or weed competition.

Acknowledgments

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